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"Spectroscopic Observations of the Planets"

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During the past two years, the research supported by this grant has focussed on isotopic ratios in comets and in the atmosphere of Titan, and the determination of surface compositions of outer solar system bodies. Titan exhibits a terrestrial value of $^{12}C/^{13}C$ but $^{14}N/^{15}N$ is highly depleted compared with Earth indicating massive escape of nitrogen from Titan. The H_2O in Comets Hale-Bopp and Hyakutake is enriched in deuterium by about a factor 2 compared with ocean water (SMOW) while D/H in Hale Bopp's HCN is 14 times the SMOW value. $^{12}C/^{13}C$, $^{14}N/^{15}N$ and $^{32}S/^{34}S$ in Hale-Bopp all have terrestrial values. These results have interesting implications for the origin of comets and for the delivery of volatiles to the inner planets. We discovered evidence for transient clouds on Titan and indications of the presence of water ice on this satellite's surface. The dark leading hemisphere of Iapetus appears to be covered by a nitrogen-rich organic compound that is mixed with six-micron ice crystals and a dark, neutral substance resembling amorphous carbon.

This year we plan to improve presently available values of $^{12}C/^{13}C$ and $^{16}O/^{18}O$ on Mars, using high resolution near-IR spectra of Martian CO_2 and H_2O. We will search for evidence of depletion of ^{16}O on Titan, to see if oxygen has been escaping with nitrogen. We will continue our near-IR studies of Titan to search for new molecules, re-measure the CO abundance and improve constraints on surface composition. We will complete the analysis of the darkside material on Iapetus and initiate a program to compare this material with the dark matter on other outer solar system objects. The Gemini and Subaru 8-meter telescopes on Mauna Kea will become available in 2000, and will have spectrometers capable of recording the 2.85-4.15 μm spectrum of these small bodies. At the same time, NIRSPEC on Keck will enable a definitive investigation of atmospheric methane on Pluto and Triton and the 1-0 CO band on Titan. We plan to use the JCMT to search for evidence of H_2S on Uranus and Neptune.

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